Rainfall effects on bird–aircraft collisions at two United States airports

Steven W. Gabrey and Richard A. Dolbeer

Abstract We examined the influence of rainfall on bird–aircraft collisions at 2 major United States airports. Presence of standing water from rainfall did not increase the probability of bird–aircraft collisions at John F. Kennedy International Airport during April–October, 1986–1990. However, at O'Hare International Airport there was evidence that standing water increased collision rates. During April–October 1992–1994, collision rates were higher 1 day after ≥2.54 cm rain than at other times. Although this analysis showed no clear-cut influence of rainfall on bird–aircraft collisions, airport operations personnel, as precautionary measures, should continue efforts to remove standing water and deter bird use of puddles. Detailed long-term data on daily bird–aircraft collisions, rainfall, and bird use of standing water are needed from other airports so that a more comprehensive and generalized analysis of collisions in relation to rainfall can be made.

Key words bird-strike, Chicago, gulls, John F. Kennedy International Airport, *Larus*, New York, O'Hare International Airport, precipitation, water

Bird–aircraft collisions at airports result in delays, expensive repairs to aircraft, environmental impacts when fuel is dumped, and occasionally injury or death to passengers (Blokpoel 1976). Abiotic factors, including season, time of day, and geographic area, can increase the probability of collisions (Blokpoel 1976, Burger 1985, DeFusco 1988, Dolbeer et al. 1989, Merritt 1990, Griffin and Hoopes 1991). Recognition of those factors in bird–aircraft collisions can alert pilots and airport operations personnel to risks so corrective measures can be taken.

One factor that has generated much discussion but no objective evaluation is the presence of standing rainwater on or near runways. Birds, especially gulls (*Larus* spp.), are often attracted to these puddles as a source of fresh drinking or bathing water (Solman 1978, Dolbeer et al. 1993*a*, Buckley and Gurien 1994). Heavy rain can also force earthworms (Lumbricidae), an important food source to many birds including gulls (Vermeer 1970, Belant et al. 1993), above ground. Thus, the risk of bird–aircraft collisions may be higher during or after rain, when standing water is present on airports.

At present, only 2 United States airports have collected sufficient data to test the hypothesis that rain or standing rainwater influences the rate of bird–aircraft collisions. At John F. Kennedy International Airport (JFKIA), New York, a full-time bird patrol has maintained consistent records of bird–aircraft collisions at the airport since the 1970's (Burger 1985, Dolbeer et al. 1993*b*). At O'Hare International Airport, Chicago, Illinois, a full-time biologist (R. P. Sliwinski, U.S. Dep. Agric., Anim. Damage Control [USDA/ADC]) began keeping similar records in 1992. Our objective was to use these bird–aircraft collision data and rainfall data from JFKIA and O'Hare to test the null hypothesis that daily bird–aircraft collision rates are unaffected by time (days) after rain.

Methods

We used records of the dates, species, number of birds involved in collisions (an aircraft striking ≥1 bird) and number of aircraft movements (an aircraft landing or departing) for JFKIA from 1986 to 1990 and for O'Hare from 1992 to 1994. Bird-strike data for

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JFKIA were obtained from the Port Authority of New York and New Jersey (PANYNJ); data for O'Hare were obtained from the USDA/ADC biologist at O'Hare. We obtained aircraft movement data from Lampl (1995) and the Port Authority of New York and New Jersey and weather data for airports from the National Climatic Data Center, National Oceanic and Atmospheric Administration, Asheville, North Carolina.

We analyzed data from each airport 3 times, using 3 levels of rain/day (≥0.25 cm, ≥1.27 cm, and ≥2.54 cm). For each analysis, we grouped dates into 1 of 7 classes, according to the number of days since rain had fallen. Dates on which a specified amount (≥0.25 cm, ≥1.27 cm, and ≥2.54 cm) of rain fell were classified as day 0, and consecutive, subsequent days in which no rain or rain of <0.25 cm fell were classified as day 1, day 2, etc. Dates that were ≥6 days since the last rain of ≥0.25 cm were classified as day ≥6. For the JFKIA data, we compared differences among the 7 classes of days after each level of rain for mean collision rate (number of aircraft striking ≥1 bird/day) and mean bird-strike rate (number of birds struck/day). Because gulls were the most frequently struck birds at JFKIA, we analyzed both variables using all bird species and using gulls only. For the O'Hare data, we analyzed only mean collision rates for all species combined because species and numbers of birds struck/collision were often not known.

We excluded data from 1 November to 31 March in all years because of confounding factors of snow and frozen water during this time. We used Kruskall-Wallis χ^2 approximation tests and Dunn's multiple comparison (Zar 1984) to compare differences among class means using Proc NPAR1WAY (SAS Inst., Inc. 1988).

Results

John F. Kennedy International Airport

Over the 1,070 days included in our analysis, 1,228 birds of 29 species were involved in 1,056 collisions with aircraft. Eighty-six percent of birds struck were gulls, and 87% of collisions involved gulls. Bird-aircraft collisions occurred in 45% of the days; collisions involving gulls occurred in 40% of the days. JFKIA averaged 911 aircraft movements/day and 10.8 bird collisions/10,000 movements.

Collision rates for the 7 classes of days following 3 levels of rain ranged from 0.5 to 1.2/day for all species and for gulls only (Table 1). No differences ($P \geq 0.41$) were detected in the mean daily collision rates among the 7 day classes for any of the 3 levels of rain. Bird-strike rates for the 7 classes of days ranged from 0.5 to 1.8/day for all species and from 0.5 to 1.7/day for gulls only (Table 2). No differences ($P \geq 0.38$) were detected in the mean daily bird-strike rates among the 7 day classes for any of the 3 levels of rain.

O'Hare

Over the 627 days included in the analysis, ≥25 bird species were involved in 253 collisions. O'Hare averaged 2,354 aircraft movements/day and 1.7 bird collisions/10,000 movements. Gulls were the most common species (34%) in the 161 collisions where a species was identified, followed by birds of prey (17%) and waterfowl (16%).

Mean number of collisions/day ranged from 0.1 to 1.0 (Table 3). No differences ($P \geq 0.20$) were detected in the mean daily collision rates among the 7 day classes for ≥0.25 cm and ≥1.27 cm of rain. However, differences in mean daily collision rates among the 7 day classes for ≥2.54 cm of rain were significant ($P = 0.05$), with day 1 having the highest mean collision rate (Table 3). Pairwise multiple comparisons were unable to determine which means differed.

Discussion

Several authors have suggested that water puddles formed after rain are a major attractant to birds at airports (Solman 1978, Griffin and Hoopes 1991, Buckley and Gurien 1994). The number of bird-aircraft collisions at airports, then, should be higher after rain. However, the importance of standing water may have been overestimated because gulls often loaf on open paved surfaces with or without standing water (Griffin and Hoopes 1991). In our study, daily mean collision rates at JFKIA were similar regardless of the number of days since ≥0.25 cm, ≥1.27 cm, or ≥2.54 cm of rain had fallen. This was also true for the daily bird-strike rates at JFKIA. In contrast, at O'Hare, daily mean collision rates were slightly higher 1 day after heavy rainfall (≥2.54 cm) than at other times. This is the time when standing water would be at a maximum.

The mean rate of 10.8 bird-aircraft collisions/10,000 movements at JFKIA was 6.4 times the rate at O'Hare (1.7/10,000 movements), and about 1.9 times the mean rate for European airports (5.7/10,000 movements; Thorpe 1990). The high rate of collisions at JFKIA relative to other airports is likely due to factors other than rain and standing water. JFKIA is adjacent to a 243-ha marsh in Jamaica Bay that in 1990 contained a 7,600-nest laughing gull (*L. atricilla*) colony (Dolbeer et al. 1993*b*). Gulls and other birds associated with these marshes and the bay often fly over the airport, regardless of weather or runway conditions. Consequently, this high population of birds

Table 1. Mean number of collisions (an aircraft striking ≥1 bird)/day at John F. Kennedy International Airport, New York, by number of rainless (<0.25 cm) days after rain of ≥0.25 cm, ≥1.27 cm or ≥2.54 cm, April–October, 1986–1990.

Days after rain	Mean (SD) collisions/day[a]								
	≥0.25 cm rain			≥1.27 cm rain			≥2.54 cm rain		
	n[b]	All birds	Gulls only	n[b]	All birds	Gulls only	n[b]	All birds	Gulls only
0	249	1.0 (1.6)	0.9 (1.6)	89	1.1 (1.7)	1.0 (1.7)	41	0.9 (1.6)	0.9 (1.6)
1	165	1.0 (1.6)	0.9 (1.6)	55	1.1 (1.8)	1.0 (1.8)	26	0.6 (1.0)	0.5 (0.9)
2	144	1.1 (1.9)	0.8 (1.9)	44	1.2 (2.3)	1.1 (2.4)	19	0.5 (1.2)	0.5 (1.2)
3	116	1.1 (2.0)	1.0 (1.8)	36	1.1 (1.9)	1.0 (1.7)	17	0.5 (1.1)	0.5 (1.1)
4	83	0.9 (1.3)	0.7 (1.3)	31	0.7 (1.0)	0.6 (1.1)	13	0.5 (0.7)	0.5 (0.7)
5	68	0.8 (1.3)	0.7 (1.2)	24	0.8 (1.3)	0.8 (1.3)	10	1.0 (1.3)	1.0 (1.3)
≥6	245	1.0 (1.8)	0.8 (1.7)	211	1.0 (1.7)	0.8 (1.7)	180	1.0 (1.5)	0.8 (1.5)
Total	1,070	1.0 (1.7)	0.9 (1.6)	490	1.0 (1.7)	0.9 (1.7)	306	0.9 (1.4)	0.8 (1.4)

[a] No difference was detected among means for the 7 day classes (χ^2 = 1.72–6.16, 6 df, $P \geq 0.41$).
[b] Number of days in sample.

may have obscured effects of rain and standing water at the airport on bird-aircraft collision rates.

The effect of standing water on the occurrence of bird-aircraft collisions also may be obscured if harassment efforts against birds are increased or if the number of aircraft movements decline during or immediately after periods of rain. There is no data on harassment effort at JFKIA or O'Hare in relation to rain to test this hypothesis. However, despite the harassment efforts of the bird patrol at JFKIA, numbers of bird-aircraft collisions continued to increase during 1986–1990 due to the proximity and growing population of the adjacent laughing gull colony (Griffin and Hoopes 1991, Dolbeer et al. 1993*b*). Although puddles of rainwater on and near the runways were assumed to contribute to the increased collision rate, we found no evidence that the mean daily collision rates at JFKIA varied with respect to time after rain and subsequent creation of puddles. The daily number of aircraft movements at major airports such as JFKIA and O'Hare usually are not influenced by rainfall although there may be short-term (e.g., 1–2 hr) fluctuations due to intense thunderstorms (J. K. Gartner, PANYNJ, JFK International Airport, Jamaica, N.Y., pers. commun.).

Although this analysis showed no clear-cut influence of rainfall on bird-aircraft collisions, there was evidence from O'Hare that collision rates may be higher 1 day after heavy (≥2.54 cm) rain, when standing water would be at a maximum. As a precautionary measure,

Table 2. Mean number of birds struck/day at John F. Kennedy International Airport, New York, by number of rainless (<0.25 cm) days after rain of ≥0.25 cm, ≥1.27 cm or ≥2.54 cm, April–October, 1986–1990.

Days after rain	Mean (SD) collisions/day[a]								
	≥0.25 cm rain			≥1.27 cm rain			≥2.54 cm rain		
	n[b]	All birds	Gulls only	n[b]	All birds	Gulls only	n[b]	All birds	Gulls only
0	249	1.2 (2.2)	1.1 (2.1)	89	1.2 (2.0)	1.1 (2.0)	41	1.2 (2.1)	1.1 (2.1)
1	165	1.4 (2.9)	1.2 (2.9)	55	1.8 (4.1)	1.7 (4.1)	26	1.3 (3.9)	1.2 (3.9)
2	144	1.1 (2.0)	1.0 (2.0)	44	1.8 (2.3)	1.1 (2.4)	19	0.5 (1.2)	0.5 (1.2)
3	116	1.2 (2.3)	1.1 (2.1)	36	1.3 (2.7)	1.2 (2.5)	17	0.5 (1.1)	0.5 (1.1)
4	83	1.0 (1.6)	0.8 (1.4)	31	0.8 (1.2)	0.7 (1.3)	13	0.5 (0.7)	0.5 (0.7)
5	68	0.9 (1.4)	0.8 (1.3)	24	1.0 (1.4)	0.9 (1.4)	10	1.1 (1.4)	1.1 (1.4)
≥6	245	1.0 (2.0)	0.9 (1.9)	211	1.1 (2.1)	1.0 (2.0)	180	1.2 (2.3)	1.0 (2.3)
Total	1,070	1.1 (2.2)	1.0 (2.1)	490	1.2 (2.4)	1.1 (2.1)	306	1.1 (2.3)	1.0 (2.3)

[a] No difference was detected among means for the 7 day classes (χ^2 = 1.48–6.38, 6 df, $P \geq 0.38$).
[b] Number of days in sample.

Table 3. Mean number of collisions (an aircraft striking >1 bird)/day at O'Hare International Airport, Chicago, Illinois, by number of rainless (<0.25 cm) days after rain of ≥0.25 cm, ≥1.27 cm or ≥2.54 cm, April–October, 1992–1994.

Days after rain	Mean (SD) collisions/day					
	≥0.25 cm rain		≥1.27 cm rain		≥2.54 cm rain	
	n[a]	All birds	n[a]	All birds	n[a]	All birds
0	114	0.4 (0.7)	43	0.4 (0.7)	20	0.4 (0.6)
1	81	0.5 (0.8)	30	0.5 (0.9)	13	1.0 (1.1)
2	70	0.4 (0.6)	29	0.3 (0.5)	13	0.4 (0.5)
3	58	0.4 (0.8)	25	0.2 (0.5)	12	0.1 (0.3)
4	52	0.5 (0.7)	22	0.4 (0.7)	9	0.2 (0.4)
5	41	0.5 (0.7)	17	0.8 (0.8)	8	0.8 (0.9)
≥6	211	0.3 (0.6)	69	0.4 (0.6)	21	0.4 (0.4)
Total	627	0.4[b] (0.7)	235	0.4[b] (0.7)	96	0.4[c] (0.7)

[a] Number of days in sample.

[b] No difference was detected among means for the 7 day classes ($\chi^2 = 7.45–8.53$, 6 df, $P \geq 0.20$).

[c] A difference was detected among means for the 7 day classes ($\chi^2 = 12.72$, 6 df, $P = 0.05$).

airport operations personnel should attempt to remove standing water and to deter bird use of puddles. Detailed long-term data on daily bird-aircraft collisions, rainfall, and bird use of standing water are needed from other airports so that a more comprehensive analysis of collisions in relation to rainfall can be made.

Acknowledgments. Funding for this study was provided by the Federal Aviation Administration (FAA), Office of Airports Safety and Standards, Washington, D.C., and Airports Division, Airport Technology Branch, FAA Technical Center, Atlantic City International Airport, New Jersey. We acknowledge the support and advice of T. H. Hupf, FAA. S. D. Garber, PANYNJ, provided the JFKIA bird-strike data. R. P. Sliwinski, U.S. Department of Agriculture/Animal Damage Control, provided the O'Hare bird-strike data and critically reviewed earlier versions of the manuscript.

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